FOREST INSECT AND DISEASE MANAGEMENT/ **evaluation report**

The Impact of Orthene,® A Spruce Budworm Insecticide on Aquatic Macroinvertebrates in Maine, 1977

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NA-FR-7
USDA Forest Service
Northeastern Area, State and Private Forestry
Broomall, Pennsylvania 19008
June 1979

ACKNOWLEDGMENTS

Funding for this study was provided by the United States Department of Agriculture Forest Service Cooperative Agreement No. 42-235. The project was a part of a cooperative effort between the Department of Entomology and the Maine Cooperative Fisheries Research Unit. Although funding was provided from two sources, a common study area for the two groups provided an opportunity to share resources, people, and ideas which resulted in a more complete study than if each group had worked independently.

Leon Tsomides and Jane Rosinski admirably assisted in all phases of the project. We appreciate the assistance of the Maine Department of Inland Fisheries and Game for the use of the Lily Bay warden's camp.

ABSTRACT

A study to examine the effects of operational spraying of the spruce budworm insecticide Orthene applied at the rate of 8 oz./acre on aquatic invertebrates was conducted near Moosehead Lake, Maine, during the spring of 1977. The effect of the insecticide on the fauna was both moderate and transitory. The standing crop of different stream habitats appeared unaffected by the spray. An increase in stream invertebrate drift developed for a period of time after spraying. Invertebrate community structure of ponds in the treated area was unaffected but there is a possibility that the spray did not enter the ponds. It is concluded that Orthene has less impact on aquatic invertebrates than most other insecticides currently registered for spruce budworm control in Maine.

CONTENTS

INTRODUCTION

The first operational spraying of the chemical acephate (Orthene)[1] to reduce damage caused by the spruce budworm (*Choristoneura fumiferana*) to spruce and fir trees in Maine was conducted during the spring of 1977. Of the approximately 930,000 acres treated with various chemicals, 63,000 were sprayed with Orthene. This insecticide was chosen because of its reputed low toxicity to aquatic life (USDA Forest Service 1977).

The goal of the study was to determine the effects of the operational spraying of Orthene on the macroinvertebrate community of streams and ponds. The specific objectives were to determine short-term alterations in community structure of streams and ponds, standing crop reductions in streams, and alterations of normal drift patterns in streams.

THE STUDY AREA

The streams selected for study were the three most similar streams in the study area. The two treated streams, North Brook and South Brook, entered Moosehead Lake on the east shore whereas the control, Squaw Brook, entered the lake on the south shore (Fig. 1). The treated streams were sampled within 500 m of where they crossed the East Shore Logging Road whereas Squaw Brook was sampled within 500 m of Route 15.

The streams averaged 5 to 7 m in width with alternating shallow pools and riffle areas. Bottom materials were typically medium to large rubble. Discharges were from 0.5 to 1 m^3/s during the week of spraying (Table 1). All streams were chemically similar with low dissolved constituents as determined by hardness, alkalinity, and conductivity (Table 2). All streams had low color values and low turbidity (Table 2).

Nearer the lake, stream current velocity slowed and a soft substratum was present. These areas were sampled and were named North Brook deadwater and South Brook deadwater. A similar sample area in the control stream, named Squaw Brook deadwater, was established upstream behind an old dam.

Two small ponds, each less than an acre, were selected to examine the effect of Orthene on invertebrates of lotic systems. These ponds were named Beaver Cove Pond and Tussle Pond.

Diurnal temperature fluctuations are typically large during late May and early June in small northern Maine streams; there were daily variations from 5° to 6° in the study streams during the spray period (Table 3).

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[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

Figure 1.—The study area with the treated area crosshatched.

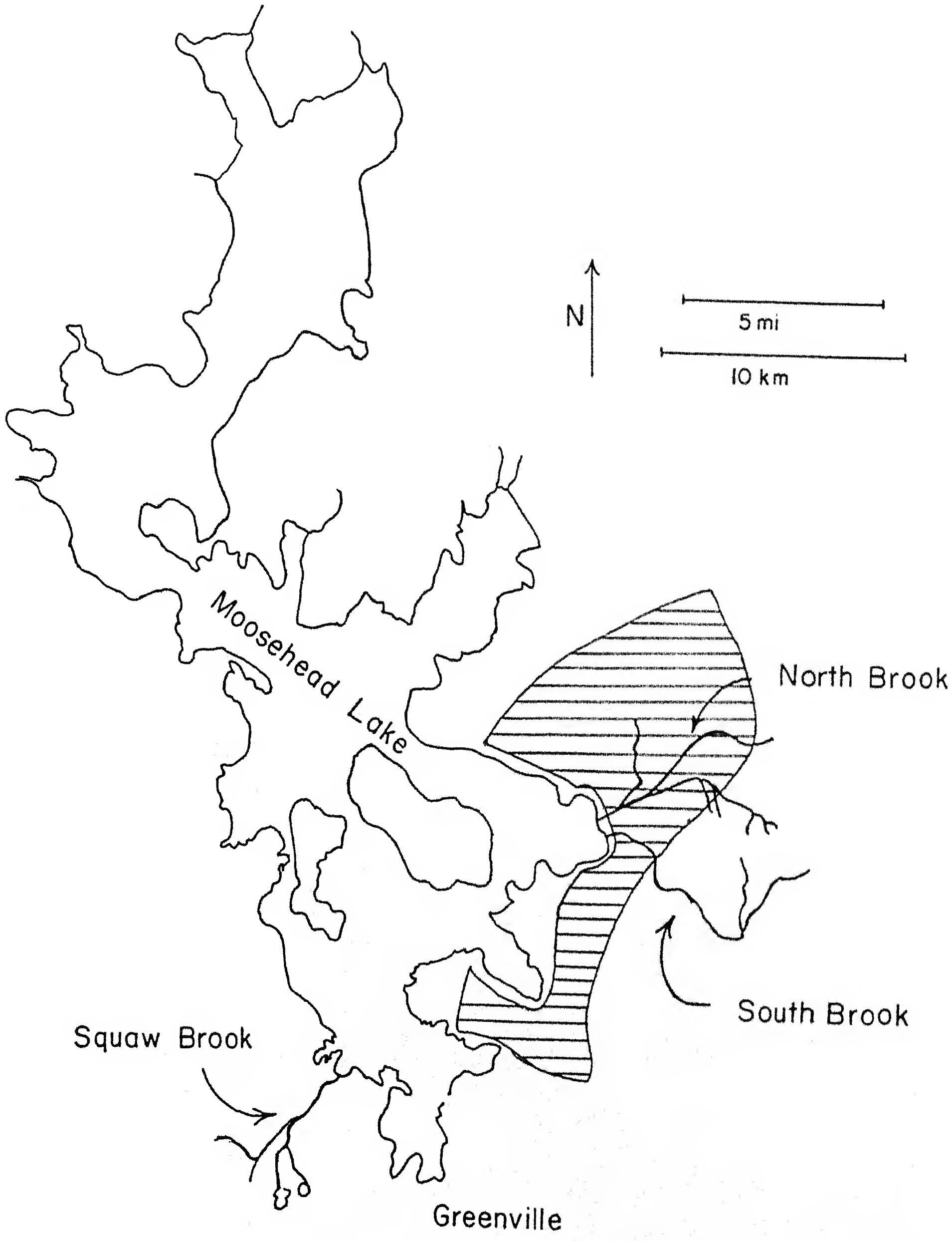

Table 1. *Stream discharges (m^3/s) on selected dates.*

Brook	June 9	July 6
North	0.6	0.7
South	1.1	.7
Squaw	.4	.9

Table 2. *Environmental features of the study streams on selected dates.*

Item	North Brook		South Brook		Squaw Brook	
	June 8	Aug 4	June 8	Aug 4	June 8	Aug 4
O_2 (ppm)	—	10.5	—	9.4	—	9.8
pH	—	6.4	—	6.2	—	6.6
Conductivity (μ mho at 25°C)	23	26	22	24	34	42
Hardness (mg/l $CaCO_3$)	5	6	5	6	9	10
Alkalinity (mg/l $CaCO_3$)	4	10	4	9	7	12
Water color (platinum scale)	10	<10	25	<10	10	<10
Turbidity (NTU's)	.33	.38	.41	.89	.40	57

Table 3. *Water temperature of study streams during the period of the most intensive sampling (°C).*

Date	Measurements taken between	North Brook	South Brook	Squaw Brook
29 May	09:15 - 11:15	4.5	6.0	7.0
30 May	12:35 - 14:25	9.0	10.5	10.0
	17:55 - 18:30	7.0	10.5	—
31 May	04:55 - 10:05	5.0	7.5	10.0
	08:25 - 09:05	6.0	8.0	—
	11:05 - 11:45	8.0	10.0	—
	13:40 - 14:30	12.0	12.5	—
	15:40 - 16:30	12.0	12.5	—
	17:40 - 18:25	10.5	13.0	—
	22:00 - 23:00	9.0	11.0	—
1 June	03:00 - 13:40	6.0	10.0	13.0
	07:20 - 08:20	6.5	9.5	—
	11:30 - 12:25	9.5	11.0	—
	17:55 - 18:30	10.0	13.5	—
2 June	08:00 - 11:15	8.0	12.0	11.0
3 June	08:30 - 9:45	7.0	10.0	10.0

METHODS AND MATERIALS

Chemical application was made by helicopter at the rate of 8 oz per acre a.i. (active ingredient) between 6:30 and 8:15 A.M. on May 31, 1977. The flight paths were south to north and the chemical was applied first to the headwater areas and last to the area nearest the lake. Project personnel were stationed at the study area and observed spray deposition.

Residue in Water

Water samples for residue analysis were taken in plastic gallon jugs and frozen within 3 hours. Water samples were taken prespray and 1 and 2 days postspray. The containers were later transported to the Maine Department of Human Services in Augusta where analyses were completed by personnel of the water quality laboratory according to the method supplied by the Chevron Chemical Company.

Macroinvertebrate Drift

Invertebrate drift samples were obtained from the 3 study streams over an 8-day period. Drift nets (1 ft^2) were placed in midstream for 15-minute intervals. Control stream (Squaw Brook) samples were taken daily. In each treated stream, 18 samples were taken at intervals ranging from daily to every 2 hours. Discharge through the nets was calculated for each collection and the results were standardized to adjust for different amounts of water filtered. Samples were sorted and the invertebrates were identified to genus.

Macroinvertebrate Standing Crop

Invertebrate standing crop from riffle areas was estimated using a Surber sampler. Similar areas from each stream were selected and 9 samples each were taken prespray, 2 days postspray, and 9 days postspray. The samples were preserved separately and later the fauna was identified to genus.

Samples from ponds and deadwater areas of the streams that had soft depositional substrates were taken with a standard aquatic D-frame net. The samples were treated identically to those from the stream.

RESULTS AND DISCUSSION

Orthene Concentration in Streams

The chemical was not detected in the streams before spraying, and it reached the measured maximum within 1 hour of application (Table 4). The pesticide remained in the treated streams for at least 2 days after spraying. No residues were detected in the pond waters or muds from the ponds or deadwaters in samples taken the day of spraying.

Table 4. *Pesticide concentrations in the study area (ppb).*

Period of collection	North Brook (treated)	South Brook (treated)	Squaw Brook (control)	Beaver Cove Pond	Tussle Pond
Prespray	—	—	—	—	—
Postspray 1 hour	135.3	113.2	—	—	—
Postspray 1 day	12.7	65.0	—	—	—
Postspray 2 days	40.8	9.8	—	—	—

Invertebrate Standing Crop of Riffle Areas

There was a reduction in the total numbers of invertebrates in the first postspray sample in North Brook, due primarily to a reduction in mayflies, and in South Brook, due primarily to a reduction in caddisflies and mayflies (Table 5). All groups had returned to prespray levels by the 9-day post spray collection. The variation in benthic invertebrate collections using the Surber sampler is usually high and this study was no exception. Many of the standard deviations were at least as large as the mean (Tables 6, 7, and 8). The fact that there was no consistent pattern between those taxa which were reduced in standing crop and their increase in the drift leads us to conclude that there was no detectable effect of the insecticide on invertebrate standing crop.

Invertebrate Drift

The invertebrate drift from the control brook (Squaw) was consistently low with little variation and was comprised primarily of Ephemeroptera, Diptera, and Trichoptera. Terrestrial forms were uncommon. The two treated streams showed an increase in drift after spraying (Fig. 2). North Brook showed an increase in total drift over any prespray sample in five of the first seven postspray collections. This increase was due almost exclusively to an increase in black flies (*Simulium* sp.) (Table 9). There was a small increase in the numbers of the mayfly genus *Baetis* and in the nonbiting midges (Chironomidae).

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Table 5. *Mean standing crop and standard deviations of the major invertebrate groups collected by 9 Surber samples. Only groups with a mean greater than 1/sample are included.*

Fauna	Prespray 5/25/77	Postspray 6/2/77	Postspray 6/9/77
	NORTH BROOK (TREATED)		
Ephemeroptera	19.3 ± 15.3	12.4 ± 7.6	20.3 ± 14.0
Trichoptera	4.3 ± 4.9	2.8 ± 2.7	5.6 ± 5.3
Diptera	8.0 ± 12.3	6.4 ± 5.4	12.7 ± 9.5
	SOUTH BROOK (TREATED)		
Plecoptera	3.4 ± 2.9	3.6 ± 2.1	3.9 ± 6.4
Ephemeroptera	17.2 ± 11.2	12.2 ± 5.4	21.1 ± 12.9
Trichoptera	13.8 ± 12.5	5.1 ± 5.8	12.9 ± 8.5
Diptera	20.9 ± 16.7	21.2 ± 14.3	17.7 ± 11.9
Coleoptera	4.3 ± 3.5	1.7 ± 1.0	2.9 ± 5.1
Megaloptera	4.3 ± 3.8	2.7 ± 2.2	1.3 ± 1.2
Pelecypoda	.8 ± .8	2.2 ± 2.6	4.2 ± 3.7
Oligochaeta	5.2 ± .8	2.4 ± 2.3	3.9 ± 8.5
	SQUAW BROOK (CONTROL)		
Ephemeroptera	11.6 ± 6.0	9.3 ± 7.5	17.1 ± 9.8
Trichoptera	8.0 ± 6.4	7.1 ± 4.1	13.8 ± 9.4
Diptera	7.2 ± 5.2	14.4 ± 23.0	33.6 ± 44.7

Table 6. *North Brook mean standing crop and standard deviations of invertebrate fauna collected by nine Surber samples at each date.*

Fauna	Prespray 5/25/77	Postspray 1 day	Postspray 9 days
PLECOPTERA			
Pteronarcidae	—	—	—
Pteronarcys	.11 ± 0.33	—	—
Leuctridae	—	—	—
Leuctra	—	—	0.11 ± 0.33
Perlodidae	—	—	—
Isoperla	.56 ± .88	0.22 ± 0.44	—
Chloroperlidae	—	—	—
Alloperla	.11 ± .33	.11 ± .33	—
EPHEMEROPTERA			
Heptageniidae	.44 ± .88	.67 ± 1.0	2.33 ± 2.29
Epeorus	9.10 ± 7.85	3.89 ± 2.89	8.56 ± 6.04
Heptagenia	1.44 ± 2.07	.56 ± .73	1.00 ± 1.32
Rithrogena	1.11 ± 1.69	1.11 ± 1.62	.67 ± .87
Stenonema	—	.44 ± 1.33	.22 ± .44
Baetidae	—	—	—
Baetis	1.78 ± 1.64	2.50 ± 2.07	2.22 ± 1.92
Leptophlebiidae	—	—	—
Paraleptophlebia	—	.11 ± .33	—
Ephemerellidae	—	—	—
Ephemerella	5.44 ± 5.55	3.33 ± 2.83	5.33 ± 4.88
TRICHOPTERA			
Hydropsychidae	—	—	—
Cheumatopsyche	—	—	.11 ± .33
Hydropsyche	.44 ± .73	.22 ± .44	.11 ± .33
Rhyacophilidae	—	—	—
Rhyacophila	1.11 ± 1.62	.22 ± .44	.56 ± .73
Glossosomatidae	—	—	—
Glossosoma	1.22 ± 1.79	1.44 ± 1.81	2.78 ± 2.95
Brachycentridae	—	—	—
Brachycentrus	.89 ± 1.05	.56 ± 1.33	1.67 ± 2.55
Micrasema	.11 ± .33	.11 ± .33	—
Limnephilidae	—	—	—
Neophylax	.22 ± .44	.11 ± .33	—
TRICHOPTERA pupa	.22 ± .67	.11 ± .33	.33 ± 1.0
DIPTERA			
Tipulidae	—	—	—
Antocha	.78 ± 1.64	.22 ± .44	.89 ± 2.32
Hexatoma	.11 ± .33	—	.44 ± .73

CONTINUED

Table 6.—Continued

Fauna	Prespray 5/25/77	Postspray 1 day	Postspray 9 days
DIPTERA—Continued			
Rhagionidae			
Atherix variegata	—	.22 ± .44	—
Blephariceridae	—	—	—
Blepharicera	—	.67 ± 1.41	.33 ± .71
Chironomidae	1.67 ± 3.20	1.67 ± 1.87	2.56 ± 3.88
Simuliidae	4.78 ± 9.80	4.00 ± 4.72	8.67 ± 10.87
ODONATA			
Gomphidae	—	.11 ± .33	—
COLEOPTERA			
Elmidae	—	—	—
Oulimnus	.11 ± .33	.22 ± .44	—
Promoresia	.11 ± .33	.11 ± .33	—
ANNELIDA			
Oligochaeta	.78 ± 1.56	—	—

Table 7. *South Brook mean standing crop and standard deviations of invertebrate fauna collected by nine Surber samples at each date.*

Fauna	Prespray 5/26/77	Postspray 1 day	Postspray 9 days
PLECOPTERA			
Pteronarcidae	—	—	—
Pteronarcys	0.22 ± 0.67	0.33 ± 0.50	—
Leuctridae			
Leuctra	2.11 ± 2.09	2.44 ± 2.29	1.67 ± 3.54
Paraleuctra	—	—	.67 ± 2.00
Perlidae	—	—	—
Phasganophora	.67 ± .71	.67 ± 1.00	.78 ± 1.56
Perlodidae	—	—	—
Isoperla	.44 ± .88	.11 ± .33	.44 ± 1.01
EPHEMEROPTERA			
Heptageniidae	.22 ± .44	.22 ± .44	.33 ± .50
Epeorus	2.11 ± 2.09	.67 ± .71	3.56 ± 3.78
Heptagenia	.22 ± .67	—	—
Stenonema	1.67 ± 1.50	1.44 ± 1.88	1.11 ± 1.05
Potamanthidae	—	—	—
Potamanthus	—	—	.11 ± .33
Baetidae	—	—	—
Baetis	.67 ± 1.12	.11 ± .33	.33 ± .71

CONTINUED

Table 7.—Continued

Fauna	Prespray 5/26/77	Postspray 1 day	Postspray 9 days
EPHEMEROPTERA—Continued			
Leptophlebiidae	—	.11 ± .33	.56 ± .73
Paraleptophlebia	.11 ± .33	1.00 ± 1.00	1.67 ± 1.58
Habrophlebia	—	.44 ± .73	.33 ± 1.00
Ephemerellidae	—	—	—
Ephemerella	12.22 ± 10.56	8.22 ± 4.47	13.11 ± 9.05
TRICHOPTERA	.33 ± .50	.11 ± .33	.11 ± .33
Hydropsychidae	.44 ± .73	—	.11 ± .33
Cheumatopsyche	1.78 ± 1.86	.67 ± 1.00	3.11 ± 3.02
Hydropsyche	3.44 ± 5.34	.56 ± 1.01	.78 ± .97
Pupae	.78 ± 1.09	.22 ± .44	.22 ± .44
Rhyacophilidae	—	—	—
Rhyacophila	.11 ± .33	—	.11 ± .33
Polycentropodidae	—	—	—
Polycentropus	.78 ± .97	.44 ± 1.01	.78 ± 1.30
Glossosomatidae	—	—	—
Glossosoma	.78 ± .97	.33 ± .50	4.11 ± 2.98
Hydroptilidae	—	—	—
Hydroptilla	—	.67 ± 2.00	—
Agraylea	—	—	.33 ± .71
Brachycentridae	—	—	—
Brachycentrus	.11 ± .33	.44 ± 1.01	.22 ± .67
Micrasema	—	—	—
Philopotamidae	4.89 ± 6.03	1.33 ± 2.12	1.89 ± 2.42
Dolophilodes	—	—	.56 ± 1.13
Limnephilidae	—	—	—
Neophylax	.22 ± .44	—	—
Goera	.11 ± .33	—	—
Lepidostomatidae	—	.22 ± .44	.44 ± .73
Lepidostoma	—	—	—
Leptoceridae	—	—	—
Ceraclea	—	.11 ± .33	—
Mystacides	—	—	.11 ± .33
DIPTERA			
Tipulidae	—	—	—
Antocha	1.00 ± 1.66	.67 ± .71	1.56 ± 1.24
Dicranota	—	—	.22 ± .44
Hexatoma	.33 ± .50	.11 ± .33	—
Rhagionidae	—	—	—
Atherix variegata	.44 ± .53	.44 ± .53	.33 ± .71
Chironomidae	18.22 ± 14.99	19.00 ± 13.79	14.89 ± 11.32

CONTINUED

Table 7—Continued

Fauna	Prespray 5/26/77	Postspray 1 day	Postspray 9 days
DIPTERA—Continued			
Simuliidae	—	.44 ± 1.01	.44 ± .73
Ceratopogonidae	—	—	—
Palpomyia	.11 ± .33	.11 ± .33	—
Epididae	.67 ± .71	.56 ± .73	.22 ± .67
ODONATA			
Gomphidae	.22 ± .67	.44 ± .73	.11 ± .33
Stylogomphus	—	.22 ± .44	.11 ± .33
Aeshnidae	—	—	—
Boyeria	.11 ± .33	.22 ± .44	—
Libellulidae	—	—	.11 ± .33
COLEOPTERA			
Elmidae	—	—	—
Oulimnus	.56 ± .73	.22 ± .44	.33 ± .71
Promoresia	3.78 ± 3.83	1.33 ± 1.00	2.56 ± 4.48
MEGALOPTERA			
Sialis	.22 ± .44	—	.11 ± .33
Nigronia	4.11 ± 3.69	2.67 ± 2.24	1.22 ± 1.20
PELECYPODA	.78 ± .83	2.22 ± 2.64	4.22 ± 3.70
ANNELIDA			
Oligochaeta	5.22 ± 3.25	2.44 ± 2.30	3.89 ± 8.52

Table 8. *Squaw Brook mean standing crop and standard deviations of invertebrate fauna collected by nine Surber samples at each date.*

Fauna	Prespray 5/26/77	Postspray 1 day	Postspray 9 days
PLECOPTERA			
Pteronarcidae	—	—	—
Pteronarcys	—	—	0.22 ± 0.67
Leuctridae	—	—	—
Leuctra	0.11 ± 0.33	—	—
Perlidae	—	—	—
Acroneuria	—	—	.11 ± .33
Phasgonophora	.33 ± .50	0.56 ± 0.88	1.33 ± 1.12
Paragnetina	—	.22 ± .44	—
Perlodidae	—	—	—
Isoperla	—	—	.11 ± .33

CONTINUED

Table 8—Continued

Fauna	Prespray 5/26/77	Postspray 1 day	Postspray 9 days
PLECOPTERA—Continued			
Chloroperlidae	—	—	—
Alloperla	.11 ± .33	.11 ± .33	.11 ± .33
EPHEMEROPTERA	.11 ± .33	—	—
Heptageniidae	.11 ± .33	.22 ± .67	.67 ± .87
Epeorus	7.44 ± 4.07	4.33 ± 3.64	7.56 ± 4.72
Heptagenia	—	—	.22 ± .44
Rithrogena	2.22 ± 1.92	.22 ± .44	.11 ± .33
Stenonema	—	—	.22 ± .67
Arthroplea	.11 ± .33	—	—
Ameletus	.11 ± .33	—	—
Baetidae	—	—	—
Baetis	.22 ± .44	2.22 ± 2.86	1.78 ± 1.92
Leptophlebiidae	—	—	—
Paraleptophlebia	.11 ± .33	.22 ± .44	1.67 ± 1.80
Ephemerellidae	—	—	—
Ephemerella	1.22 ± 1.09	2.00 ± 1.58	4.56 ± 4.53
TRICHOPTERA	.22 ± .44	—	—
Hydropsychidae	.11 ± .33	—	.11 ± .33
Cheumatopsyche	—	.11 ± .33	.78 ± 1.39
Hydropsyche	5.67 ± 4.66	5.33 ± 3.67	9.89 ± 725
Pupae	1.22 ± 2.39	.78 ± 1.97	.56 ± 1.01
Rhyacophilidae	—	—	—
Rhyacophila	—	.22 ± .44	.22 ± .67
Polycentropodidae			
Polycentropus	.11 ± .33	.22 ± .44	.56 ± .88
Philopotamidae	.11 ± .33	—	—
Dolophilodes	—	—	.78 ± 1.99
Glossosomatidae	—	—	—
Glossosoma	.33 ± .71	.33 ± .50	.22 ± .44
Brachycentridae	—	—	—
Brachycentrus	—	—	.11 ± .33
Micrasema	.11 ± .33	—	—
Lepidostomatidae	—	—	—
Lepidostoma	.11 ± .33	.11 ± .33	.56 ± .73
DIPTERA			
Tipulidae	—	—	—
Antocha	.11 ± .33	.11 ± .33	.11 ± .33
Hexatoma	—	.11 ± .33	.11 ± .33
Rhagionidae	—	—	—
Atherix variegata	.11 ± .33	—	—

CONTINUED

Table 8—Continued

Fauna	Prespray 5/26/77	Postspray 1 day	Postspray 9 days
DIPTERA—Continued			
Blephariceridae			
Blepharicera	2.56 ± 3.21	3.00 ± 4.39	1.78 ± 4.60
Chironomidae	3.44 ± 3.94	1.78 ± 1.72	15.67 ± 16.47
Simuliidae	1.00 ± 1.50	9.33 ± 17.42	15.67 ± 29.40
Empididae	—	.11 ± .33	.22 ± .44
ODONATA			
Gomphidae	—	.11 ± .33	—
COLEOPTERA			
Elmidae	—	—	—
Oulimnus	.33 ± 1.00	—	.11 ± .33
Optioservus	—	.11 ± .33	—
Dubiraphia	.11 ± .33	—	—
Promoresia	—	.11 ± .33	—
MEGALOPTERA			
Nigronia	.11 ± .33	.11 ± .33	—
PELECYPODA	.11 ± .33	.22 ± .44	.78 ± .67
FISH	2.78 ± 5.76	.11 ± .33	.89 ± 1.69
eggs	12.67 ± 21.54	9.44 ± 10.16	10.67 ± 17.85
TERRESTRIALS	—	—	.11 ± .33

Figure 2.—Invertebrate drift collected from the study streams.

Table 9. *Invertebrate drift individual numbers collected in 15-minute samples from North Brook, by date and time.*

Fauna	May													June					
	27 1600	28 1320	29 0915	30 1425	30 1755	31 0455		31 0825	31 1105	31 1340	31 1540	31 1730	31 2200	1 0300	1 0720	1 1225	1 1830	2 0830	3 0945
PLECOPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—
Leuctra	—	—	—	—	—	—		—	—	—	—	—	1	—	—	—	—	—	—
Isoperla	—	—	—	—	—	—		—	1	—	—	—	1	2	—	—	—	—	—
Alloperla	—	—	1	—	—	—		—	—	—	—	—	—	—	2	—	—	—	—
EPHEMEROPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—
Epeorus	—	—	—	—	—	1	S	2	—	1	—	—	—	—	—	—	2	—	—
Rithrogena	—	—	—	1	—	—	P	—	—	—	—	—	1	—	—	—	—	—	—
Ameletus	—	—	—	—	—	—	R	—	—	—	—	—	1	—	—	—	—	—	—
Litobrancha	—	—	—	—	—	—	A	—	—	—	—	—	—	1	—	—	—	—	—
Baetis	—	—	—	2	2	1	Y	1	1	3	—	—	8	7	—	—	—	1	1
Paraleptophlebia	—	—	—	—	—	—		—	—	—	—	—	1	—	—	—	—	—	—
Ephemerella	1	—	—	—	—	—		1	—	—	—	—	—	1	—	—	—	—	—
TRICHOPTERA	—	—	—	—	—	—	D	—	—	—	—	—	—	—	—	—	—	—	—
Cheumatopsyche	—	—	—	1	—	—	A	1	—	—	1	1	1	—	1	—	—	1	—
Micrasema	—	—	—	1	—	—	Y	—	1	—	—	1	1	—	—	—	—	—	—
Pycnopsyche	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	1	—	—
Lepidostoma	—	—	—	—	—	—		—	—	—	1	—	—	—	—	—	—	—	—

DIPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—
Chironomidae	1	1	—	—	—	—		3	2	—	—	—	—	2	1	—	4	1	—
Stratyomyidae	—	—	—	—	—	—		—	—	—	—	—	—	1	—	—	—	—	—
Simuliidae	21	8	2	11	—	6		16	33	29	4	3	193	44	9	15	3	14	6
COLEOPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—
Oulimnius	—	—	—	—	—	—	S	—	—	—	—	—	—	—	1	—	—	—	—
Promoresia	1	—	—	1	—	—	P	—	1	2	1	—	1	—	1	1	—	—	—
Palpomyia	—	—	—	1	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—
HEMIPTERA	—	—	—	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—
		-	—	1	—	—	Y	—	1	—	—	—	—	1	1	—	1	—	—
			-	—	1	—		—	—	—	—	—	—	—	—	—	—	—	—
				—	—	—		—	—	—	—	—	—	1	1	—	—	—	—
				6	2	—	D	—	2	3	1	—	—	—	2	—	—	2	—
				—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—
				—	—	—	Y	2	2	—	—	—	—	—	—	—	—	—	—
				—	—	—		1	1	1	1	—	—	—	2	—	2	2	1
				—	—	1		1	—	6	8	2	3	—	1	5	2	—	2
				—	—	—		—	—	—	—	—	—	—	1	—	—	—	—

Table 10. *Invertebrate drift individual numbers collected in 15-minute samples from South Brook, by date and time.*

Fauna	May													June						
	27 1445	28 1420	29 2155	30 1345	30 1830	31 0530		31 0905	31 1145	31 1430	31 1630	31 1825	31 2300	1 0340	1 0820	1 1135	1 1755	2 0800	3 0830	3 0915
PLECOPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Leuctra	—	—	1	—	—	—		—	—	—	—	—	1	—	—	—	—	—	—	—
Phasganophora	—	—	1	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Isoperla	—	—	—	—	—	—		—	—	—	—	1	—	—	—	—	—	—	—	—
Alloperla	—	—	1	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	
EPHEMEROPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Epeorus	—	—	—	—	—	—	S	—	—	—	—	—	—	1	—	—	—	—	—	—
Stenonema	—	—	—	—	—	—	P	—	—	—	—	—	—	—	1	—	—	—	—	—
Baetis	—	—	1	—	—	—	R	—	—	1	—	—	2	—	—	—	—	—	—	—
Paraleptophlebia	—	—	4	—	—	—	A	—	—	—	—	—	—	1	—	—	—	—	—	1
Habrophlebia	—	—	—	—	—	—	Y	—	—	—	—	—	—	1	—	—	—	—	—	—
Ephemerella	—	—	17	—	—	—		1	—	2	—	—	—	—	—	1	1	—	1	1
TRICHOPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Rhyacophila	—	1	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Polycentropus	—	—	—	—	—	—	D	—	—	—	—	—	2	—	—	—	—	—	—	—
Dolophilodes	—	—	—	—	—	—	A	—	—	—	—	—	—	—	—	—	—	1	—	—
Glossosoma	—	—	1	—	—	—	Y	—	—	—	—	—	—	—	—	—	—	—	1	—
Brachycentrus	—	—	—	—	—	—		—	—	1	—	—	1	—	—	—	—	—	—	—
Micrasema	—	—	3	—	—	1		—	—	—	—	—	3	—	—	—	—	—	—	—
Onocosmoecus	—	—	—	—	—	—		—	—	—	—	—	—	1	—	—	—	—	—	—
Lepidostoma	—	—	—	—	—	—		—	—	1	—	—	—	—	—	—	—	—	—	—

DIPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Chironomidae	—	—	5	—	—	1		—	1	3	—	—	—	2	2	4	—	—	1	—
Stratiomyidae	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	1	—
Simuliidae	1	7	2	3	2	11		4	7	1	1	1	28	21	5	7	1	—	2	1
COLEOPTERA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Oulimnius	—	—	—	—	—	—		—	—	1	—	—	—	—	—	—	—	—	—	—
Promoresia	—	—	2	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—
MEGALOPTERA	—	—	—	—	—	—	P	—	—	—	—	—	—	—	—	—	—	—	—	—
Nigronia	—	—	—	—	—	—	R	—	—	1	—	—	—	—	—	—	—	—	—	—
HEMIPTERA	—	—	—	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—	—
Gerris	—	—	—	—	—	—	Y	—	5	—	—	—	—	—	—	—	—	—	—	—
NEMATODA	—	—	1	—	—	—		—	1	—	—	—	—	—	—	—	—	—	—	—
HYDROCARINA	—	—	—	—	—	—		—	1	2	—	—	—	1	1	2	1	1	—	—
TERRESTRIALS	—	—	—	—	—	—	D	—	—	—	—	—	—	—	—	—	—	—	—	—
COLEOPTERA	—	—	—	—	—	—	A	—	1	1	—	—	1	1	—	—	—	—	—	—
HEMIPTERA	—	—	—	—	—	—	Y	—	—	—	—	—	—	—	—	1	—	—	—	—
THYSANOPTERA	—	—	—	—	—	—		—	—	1	—	—	—	—	—	—	—	—	—	—
LEPIDOPTERA	—	—	—	—	—	—		2	3	2	—	—	—	—	—	—	1	—	—	—
ARACHNIDA	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	1	1	—

Table 11. *Invertebrate drift individual numbers collected in 15-minute samples from Squaw Brook, by date and time.*

Fauna	May					June	
	27 1700	28 1530	29 1115	30 1235	31 1005	1 1340	2 1115
PLECOPTERA	—	—	—	—	—	—	—
Alloperla	—	—	—	1	—	—	—
EPHEMEROPTERA	—	—	—	—	—	—	—
Epeorus	—	2	1	—	—	—	—
Heptagenia	—	—	—	—	—	—	—
Baetis	1	1	1	2	1	—	1
Paraleptophlebia	—	1	—	—	—	1	—
Ephemerella	—	2	2	1	—	—	—
TRICHOPTERA	—	—	—	—	—	—	—
Hydropsyche	—	3	—	—	—	—	—
Dolophilodes	—	—	—	—	—	—	1
Stactobiella	—	—	—	—	—	—	1
Micrasema	—	—	—	—	—	1	—
DIPTERA	—	—	—	—	—	—	—
Antocha	—	1	—	—	1	—	—
Atherix	—	—	—	—	—	—	1
Blepharicera	—	—	—	—	1	—	—
Chironomidae	—	1	6	—	2	1	—
Simuliidae	—	—	—	—	1	—	1
NEMATODA	—	—	1	1	—	—	—
COLEOPTERA	1	—	—	—	1	—	—
HEMIPTERA	—	—	—	—	—	1	—
ARACHNIDA	—	—	1	—	—	—	—

Table 12. *Percentage of the total catch of fauna collected from the North Brook deadwater on specific days.*

Fauna	Prespray	Postspray		
	5/30/77	5/31/77	6/2/77	6/9/77
PLECOPTERA	—	—	—	—
Leuctra	09.29	—	—	—
Amphinemura	.29	—	—	—
Alloperla	.29	—	—	—
EPHEMEROPTERA	—	—	—	—
Siphlonurus	54.10	70.00	69.20	48.50
Baetis	—	—	.29	—
Paraleptophlebia	.29	—	—	—
Leptophlebia	1.73	—	.29	.34
Ephemerella	.58	—	.59	1.37
Litobrancha	.29	—	—	—
TRICHOPTERA	—	—	—	—
Brachycentrus	.29	—	—	—
Nemotaulius	1.73	2.00	.89	1.72
Limnephilus	9.82	28.00	22.80	31.30
Pycnopsyche	.29	—	—	—
Mystacides	.29	—	—	—
DIPTERA	—	—	—	—
Pilaria	.29	—	—	—
Chironomidae	18.50	—	3.59	15.10
Palpomyia	.29	—	—	—
Chrysops	.87	—	—	.34
ODONATA	—	—	—	—
Cordulegaster	.29	—	—	—
Aeshna	—	—	.29	—
COLEOPTERA	—	—	—	—
Haliplus	3.47	—	.29	—
Gyrinidae	—	—	.29	—
HEMIPTERA	—	—	—	—
Corixidae	.58	—	—	—
CRUSTACEA	—	—	—	—
Amphipoda	—	—	—	.34
MOLLUSCA	—	—	—	—
Gastropoda	3.47	—	.59	1.03
Pelecypoda	.29	—	—	—
ANNELIDA	—	—	—	—
Oligochaeta	1.73	—	.89	.34
Total number of Organisms	346	50	334	291

Table 13. *Percentage of the total catch of fauna collected from the South Brook deadwater on specific days.*

Fauna	Prespray	Postspray		
	5/30/77	5/31/77	6/2/77	6/9/77
PLECOPTERA	—	—	—	—
Leuctra	0.18	—	—	—
EPHEMEROPTERA	—	—	—	—
Siphlonurus	1.26	2.04	0.61	2.39
Heptageniidae	—	—	—	.48
Arthroplea	.18	—	—	—
Leptophlebidae	.18	—	—	—
Ephemerella	.54	—	2.44	4.30
Litobrancha	.54	—	1.82	1.44
TRICHOPTERA	—	—	—	—
Polycentropus	—	—	.61	—
Limnephilus	—	2.04	—	—
Pycnopsyche	.18	—	—	.96
Lepidostoma	.18	—	—	—
Mystacides	1.08	8.16	1.82	.48
DIPTERA	—	—	—	—
Chironomidae	64.00	83.70	43.90	20.90
Chrysops	1.08	—	—	1.44
ODONATA	—	—	—	—
Stylurus	.18	—	—	—
Aeshna	.18	—	—	—
COLEOPTERA	—	—	—	—
Haliplus	2.89	2.04	.61	—
MEGALOPTERA	—	—	—	—
Sialis	—	—	—	.48
MOLLUSCA	—	—	—	—
Gastropoda	3.97	—	5.48	10.00
Pelecypoda	22.90	—	39.60	56.90
ANNELIDA	—	—	—	—
Oligochaeta	—	2.04	1.82	—
Hirudinea	.36	—	1.23	.48
Total number of Organisms	553	49	164	209

Table 14. *Percentage of the total catch of fauna collected from the Squaw Brook deadwater on specific days.*

Fauna	Prespray	Postspray	
	5/28/77	6/2/77	6/9/77
PLECOPTERA	—	—	—
Leuctra	—	0.79	1.54
EPHEMEROPTERA	—	—	—
Siphlonurus	9.42	3.15	4.62
Heptageniidae	1.04	—	—
Epeorus	.52	—	—
Stenonema	.52	.79	—
Leptophlebiidae	1.57	—	—
Habrophlebia	.52	—	—
Leptophlebia	1.04	—	—
Ephemerella	2.09	3.15	3.08
Litobrancha	20.40	37.80	43.10
TRICHOPTERA	—	—	—
Polycentropus	—	.79	1.54
Hydactophylax	.52	—	—
Pycnopsyche	.52	.79	1.54
Molanna	1.57	.79	—
Limnephilus	.52	—	—
Nemotaulius	.52	—	—
Lepidostoma	.52	—	—
Mystacides	1.57	.79	—
DIPTERA	—	—	—
Chironomidae	42.90	25.20	3.08
Palpomyia	—	1.57	—
Tabanus	1.04	—	—
Chrysops	2.61		
ODONATA			
Calopteryx			
Cordulegaster			
Aeshna			
MEGALOPTERA			
Sialis			
CRUSTACEA			
Amphipoda			
MOLLUSCA			
Gastropoda			
Pelecypoda			
ANNELIDA			
Oligochaeta			
Hirudinea			
Total number of organisms			

Table 15. *Percentage of the total catch of fauna collected from Beaver Cove Pond on specific days.*

Fauna	Prespray	Postspray		
	5/30/77	5/31/77	6/1/77	6/9/77
EPHEMEROPTERA	—	—	—	—
Siphlonurus	2.40	—	3.60	6.78
Arthroplea	3.20	0.28	.38	4.95
Leptophlebia	.94	.09	5.20	2.93
Ephemerella	.13	—	.15	.18
Litobrancha	.13	—	.07	—
TRICHOPTERA	—	—	—	—
Phylocentropus	—	.09	—	—
Hydroptiliadae	.13	—	—	—
Limnephilus	.13	2.42	.54	2.38
Nemotaulius	—	.09	—	.55
Mystacides	—	—	.07	—
DIPTERA	—	—	—	—
Chironomidae	81.70	91.70	75.60	64.20
Tabanus	—	.18	—	—
Chrysops	1.35	.27	.07	.55
ODONATA	—	—	—	—
Aeshna	—	.09	.84	.55
Tetragoneuria	—	.09	.23	.92
MEGALOPTERA	—	—	—	—
Sialis	—	.18	.38	.73
HEMIPTERA	—	—	—	—
Corixidae	—	—	—	.18
CRUSTACEA	—	—	—	—
Amphipoda	1.35	2.42	3.91	4.60
MOLLUSCA	—	—	—	—
Gastropoda	—	.28	.99	—
Pelecypoda	6.60	1.30	6.44	9.40
ANNELIDA	—	—	—	—
Oligochaeta	1.89	.28	.46	1.10
Hirudinea	—	.18	—	—
Total number of Organisms	742	1073	1303	545

Table 16. *Percentage of the total catch of fauna collected from Tussle Pond on specific days.*

Fauna	Prespray	Postspray		
	5/29/77	5/31/77	6/2/77	6/9/77
EPHEMEROPTERA	—	—	—	—
Siphlonurus	3.97	36.20	11.90	10.00
Arthroplea	—	8.50	7.14	2.22
Leptophlebia	3.17	6.40	2.38	1.10
Ephemerella	3.97	2.12	1.58	4.44
Litobrancha	—	—	.79	—
TRICHOPTERA	—	—	—	—
Nemotaulius	3.17	—	.79	3.33
Molanna	1.58	—	1.58	1.10
Limnephilus	4.76	19.10	8.73	17.80
Pycnopsyche	2.38	—	—	1.10
Lepidostoma	1.58	4.25	—	3.33
Mystacides	.79	—	—	—
DIPTERA	—	—	—	—
Hexatoma	—	—	.79	—
Chironomidae	23.8	12.80	22.20	6.67
Chrysops	.79	—	3.17	—
ODONATA	—	—	—	—
Cordulegaster	2.38	—	—	—
Tetragoneuria	1.58	—	.79	2.22
Somatochlora	.79	—	.79	4.44
MEGALOPTERA	—	—	—	—
Sialis	1.58	—	.79	—
HEMIPTERA	—	—	—	—
Gerridae	—	2.12	—	—
CRUSTACEA	—	—	—	—
Amphipoda	17.5	6.38	22.20	14.40
MOLLUSCA				
Gastropoda				
Pelecypoda				
ANNELIDA				
Oligochaeta				
Hirudinea				
Total number of organisms				

South Brook showed an increased drift after spraying which was also primarily due to an increase in black flies (Table 10). The results from this stream are less clear because one of the prespray samples contained more organisms than many of the postspray samples. It is concluded that invertebrate drift was moderately and temporarily affected by the application of the insecticide.

Invertebrate Community Structure of Stream Deadwaters

The two treated streams were sampled near the road crossing. The control stream was sampled upstream of the riffle area above an old dam. At all sites water velocity had slowed and a soft substrate was present. The fauna was typical of a depositional habitat with the midge larvae (Chironomidae) being the most abundant group. Samples were taken prespray, on spray day, and 9 days postspray. Because of the qualitative nature of D-net collections the results are presented as percentages of the total (Tables 12-16).

An attempt to attribute population shifts of invertebrates to the effects of the insecticide must take into account the variations in population structure found in the control streams between the first and last sampling. These differences must be attributed to sampling variences.

There appeared to be a reduction of some forms in the immediate postspray collections (Tables 12, 13, and 14). Because this occurred in both treated and control streams, it must represent an artifact of the sampling. Several taxa are found in prespray samples but not in the first postspray. Those taxa not found in the postspray collections invariably represent less than 1 percent of the prespray collections. This rare taxa must be disregarded when examining for insecticide effects.

In North Brook none of the most abundant forms, *Siphlonurus* (Ephemeroptera), *Limnephilus* (Trichoptera), or Chironomidae (Diptera) showed a major decrease 9 days after spraying (Table 12). In South Brook, of those forms representing greater than 1 percent of the prespray collections, none showed a decrease in all postspray collections (Table 13).

It is concluded that there was no indication of standing crop reductions or community structure alterations in the stream deadwater areas that could be attributed to the insecticide.

Invertebrate Community Structure of Ponds

Inspection of the study ponds in the treated area was made shortly after spraying. There was no indication of any dead, dying, or otherwise distressed invertebrates. Results indicated that the community structure remained relatively stable over the 9-day sampling period. No taxon was eliminated nor did any show a consistent decline in relative abundance.

It is concluded that invertebrate community structure was not affected by the spray operation but there is a distinct possibility that the spray did not enter the ponds.

CONCLUSIONS

The effect of Orthene on aquatic macroinvertebrates in this study appeared to be moderate and transitory. The standing crop of different stream habitats appeared unaffected by the spray. An increase in drift developed for a period of time after spraying but was comprised primarily of one taxon (Diptera: Simuliidae). Invertebrate community structure of ponds in the treated area was unaffected but there is a question of whether the ponds were actually hit by the spray.

Because many of the conclusions of this study were drawn from negative evidence where no effect was noted, it is of interest to compare the effects of Orthene with the effects of other insecticides used to combat the spruce budworm in the Northeast.

Invertebrate standing crop reductions in Maine streams and ponds due to budworm spraying have been reported for DDT (Gorham 1961, Dimond 1967), Sumithion® (Accothion®) (Dimond and Malcolm 1971, Rabeni and Gibbs 1976), and Sevin® (Courtemanch and Gibbs 1977). Using similar techniques, standing crop reductions were not detected for Matacil®, Dylox® (Rabeni and Gibbs 1976), Dimilin® (Rabeni and Gibbs unpublished data), or Orthene in this study.

These results from field monitoring coincide well with laboratory toxicity studies using the same chemicals. Schoettger and Mauck (1976), using the amphipod *Gammarus pseudolimnaeus*, found the LC_{50} dosage of Orthene to be at least 1,000 times greater than that for Sumithion, Matacil, Dylox, Sevin, and Dimilin.

It has been determined that budworm insecticide may cause an increase in invertebrate stream drift, and subsequent drift mortality, without causing noticeable standing crop reductions (Eidt 1975). Pesticides in the streams at concentrations of 6.38 ppb apparently caused 10-fold increases in drifting organisms. Tenfold increases in drift were found in this study, but the concentrations of Orthene were 20 times greater (i.e., 135 ppb). Another study of a spray operation of Orthene over a small stream in New York showed no significant increase in postspray drift (Boscor and O'Connor 1975).

It is evident that Orthene has less impact on benthic invertebrates than most other insecticides used for spruce budworm control in Maine. This is not to imply, however, that its effects are unimportant. The invertebrate community was disrupted and there may have been other sublethal effects that could not be detected in a short-term study.

PESTICIDE PRECAUTIONARY STATEMENT

This publication reports evaluations involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

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